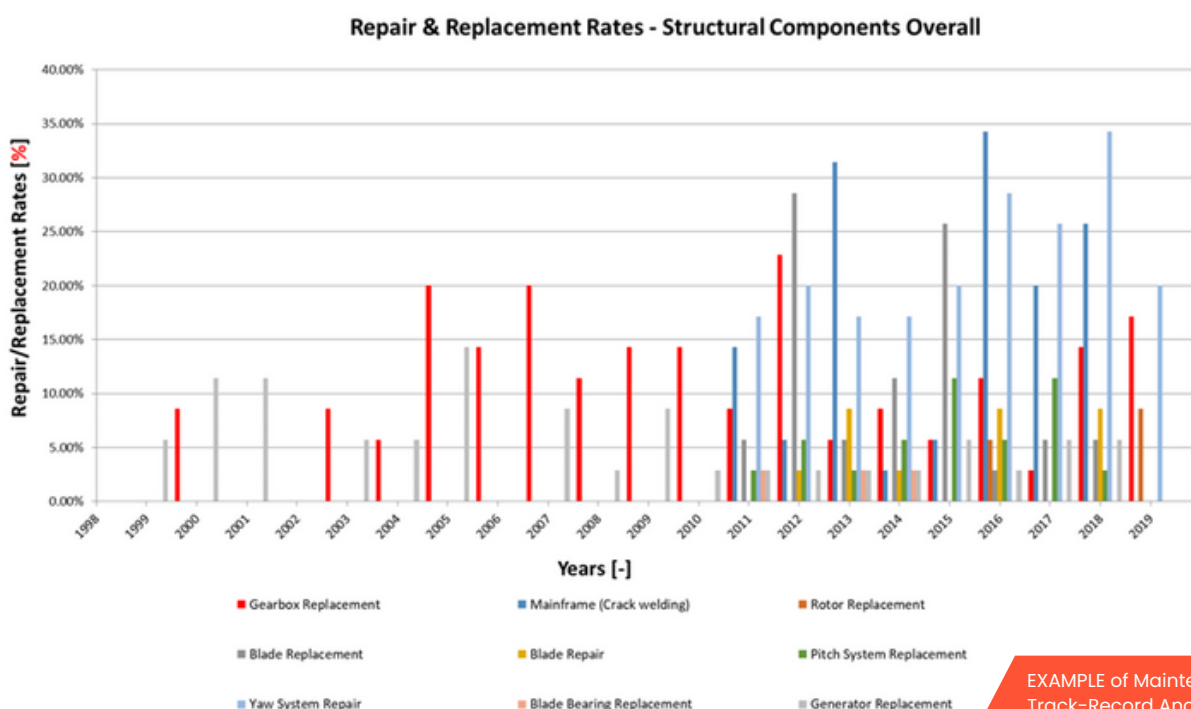# RELIABILITY MODEL

INTRODUCTION

The **Reliability Model** determines the Failure Rate Distribution per component (structural, rotational, and big electrical components), covering Fatigue and Random failures, and providing O&M Costs (CAPEX/OPEX) Distribution per component and per wind farm in extended life scenarios (to up to 40 years).

This report shows the long term risk profile of a wind asset, and can be adapted to reflect the non-covered risk under diferent O&M schemes (full scope, limited scope, others).

CONCEPT

The Reliability Model goes one step further to the typical statistical analysis of maintenance track-record, it focuses on all these "Variable" risk/costs, not included in the Competitive Standard Scope O&M, specifically:

- **Structural Components'** Corrective (CAPEX) and Preventive (additional OPEX) Actions.
- **Rotational Components'** Corrective (CAPEX) and Preventive (additional OPEX) Actions.
- **Big Electrical Components'** Corrective (CAPEX).

EXAMPLE of Maintenance Track-Record Analysis performed by nabla wind hub as one of the Inputs for the Reliability Model.

The idea behind is to give sufficient visibility to **improve the SPV's** yearly result, by adapting the Maintenance Strategies to the asset specific conditions; enabling to switch from a Full Service O&M to a Competitive Standard O&M Scope reinforced with a tailor made Long Term Strategy that takes care, through selective Ageing Management Plans, of the key components, **while reducing risk and cost.**

For such purpose, this report shows a **comparison between 2 long-term scenarios**, with and without the advantages of a Life Extension program:

01 **Long term scenario without any tailor-made preventive action**

Therefore showing the combined failure per component of Infant, Random and Fatigue, without any Ageing Management Plan per component ("letting the fatigue act" over the components without any preventive actions).

02 **Long-term scenario in which the recommendations of nabla are turned into scheduled preventive OPEX**

The Figures in these sections will show:

- a preventive OPEX line through the years (to be summed to the standard OPEX line related to O&M).
- and a lower number of CAPEX for retrofits for major components (mitigating the Fatigue Failures), together with a reduced technical uncertainty in general over the WTG.
- this scenario can be tailor-made to reflect different risk profiles/expositions (example: full scope with yearly CAPs).

METHODOLOGY

To summarize, the Reliability Model shows for the whole Wind Farm:

A **Failure Distributions (*) per component with and without Preventive Actions**: based on the failure rates along the expected life cycle per turbine component, according to the wind conditions, operation conditions and own turbine sensitivity, the model will calculate the number of components' failures per Wind Farm.

B **O&M Corrective and Preventive Costs Distribution (*) per component**: associating the Failures to the expected costs related to the specific component at the site, including:

- **Maintenance Action CBS – Cost Breakdown Structure**: including component repair/replacement costs, logistics costs, auxiliary equipment (e.g. cranes), and human technical team costs

- **Maintenance Action Downtime**: associated to the action, deriving the associated lack of benefit taking into account energy sales loss (hours lost and average energy sales price)

C **Preventive actions, classed as OPEX**, including reinforcements (preventive) and scheduled repairs (corrective, which are possible thanks to a preventive protocol). These are costs that prevent a Failure, which leads to a CAPEX (always corrective).

A **final outcome** compares the results and highlights some useful figures and ratios.

OUTCOMES

The Reliability Model will deliver all failure rate and costs distributions per component and per wind farm, assembling all of them in a common Failure Rate and Costs distribution per wind farm, providing optimal technical input for financial models.

REFERENCES

nabla wind hub is an independent technology platform that delivers asset redevelopment projects for the wind industry worldwide. End-to-end & one-stop-shop partner for SPVs and Porftolios revaluation, through Life Extension, Performance Improvement and Maintenance Optimisation; based on state of the art technologies, such as top-accuracy aeroelastic models, in-house rerotoring components, and advanced monitoring solutions.

600 wind farms assessed   **1200** sensors installed   **2000** blades installed   **+250** Wind Turbines monitored

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